SOUTH TOTO ACOUSTIC MEASUREMENT FACILITY (STAFAC) IN-WATER SYSTEMS DESIGN

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INTRODUCTION

Current submarine radiated noise measurement systems operated by the US Navy in the Southern portion of the Tongue of the Ocean (TOTO), Bahamas, including their deployment vessel, the USNS HAYES, are nearing their end-of-life and require replacement prior to FY09. The South TOTO Acoustic Facility Program, STAFAC, is a Naval Surface Warfare Center, Carderock Division (NSWCCD) program supported by the Naval Undersea Warfare Center, Newport Division (NUWCDIVNPT), which operates and maintains the Navy's Atlantic Undersea Test and Evaluation Center, (AUTEC) on Andros Island, Bahamas, and the Naval Facilities Engineering Service Center (NFESC). This four year program, beginning in FY05, replaces the existing surface ship deployed submarine radiated noise, high gain measurement systems with a fixed, bottom mounted, shore connected acoustic system installed in the same area. The main system infrastructure was installed in April through May of 2008, and the acoustic sensors were installed in July – August 2008. The Initial Operational Capability (IOC) for STAFAC is October 2008.

The Mechanical, Mooring, and Installation (MMI) Integrated Project Team, team comprised of personnel from the Naval Undersea Warfare Center (NUWC) in Newport, RI, Naval Facilities Engineering Service Center (NFESC) in Port Hueneme California, and Sound & Sea Technology (SST) in Ventura California were tasked to design, manufacture the mechanical components of the STAFAC system, and to install the entire STAFAC system, including the MMI and array components at AUTEC, Andros Island Bahamas.

Overall System Description

Figure 1 provides an overview of the wet-end components of STAFAC, which were conceived, developed, and installed by the STAFAC Mechanical, Mooring, and Installation Team. The system was required to have a 15 year service life, with access to the acoustic array sections every five years, at a minimum, for maintenance.

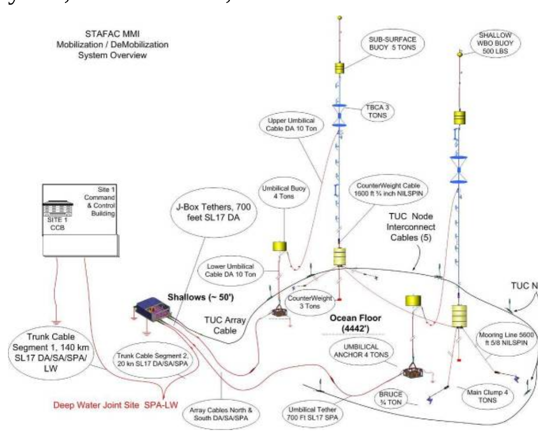

Figure 1 STAFAC Wet-End System

The STAFAC In-Water Mechanical System comprises all bottom mounted telemetry and power cables, deep sea moorings, and related mechanical subsystems incorporated into the AUTEC land and sea sites. These included undersea power and telemetry cables, electro-optical-mechanical terminations; a shallow water mounting structure for a telemetry and power conversion Junction Box; instrumentation pressure vessels; subsurface floats and suspension components; mechanical mooring cables, fittings, and assemblies; and bottom and counterweight anchors. These systems are described in the following sections.

DESCRIPTION OF MMI WET-END HARDWARE

Telemetry and Power Subsystem

The STAFAC wet-end system comprises five different ocean cable segments, as described in the following sections. **Figure 2** presents an overview

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chart of the STAFAC TYCO SL17 cables that were installed using a telecom cable ship, the C/S INTREPID, chartered from International Telecom. These include the Shore and ground cables, trunk cables, J-Box and array tether cables, array bottom cables, and Tracking and Underwater Communications (TUC) array cables.

Trunk and Ground Cables

The Trunk Cable is an electro-optical submarine telecommunications cable landed at Site 1, and installed out to the STOTO J-box location (located in the north-west section of the STOTO Cul-de-Sac). The Trunk Cable consists of two TYCO SL17 segments. Segment 1 was laid from AUTEC Site 1 to a deep water telecom joint site in the South TOTO, approximately 140 km in length. Segment 2 was joined to the STOTO J-Box Trunk Tether Cable and laid from the J-Box to the Deep Water Joint Site, approximately 20 km in length for a total Trunk Cable length of approximately 160 km. A Universal Joint splice was installed to join the two telecom cables. **Figures 3a-3d** show diagrams of the four different configurations of TYCO SL17 Cable. To ensure long life, the cable in the shore landing and STOTO J-box areas was double armored in water depths between 0 and 250 meters and single armored between 250 and 500 meters. The Trunk Cable was double armored on shore, in the shallow areas and down the steep escarpment, single armored down the slope, SPA Type (steel tape around core) through the AUTEC Weapons Range and the TOTO, and LW (lightweight) type in the Southern "Cul-de-Sac" of the TOTO.

The Trunk Ground Cable was a 2 km length of TYCO SL17 SA Cable installed from the Site 1 CCB (Command Control Building) to the shallow water area just beyond the Site 1 reef cut. It was connected to a bare steel sea water ground (cathode), anchored to the seabed.

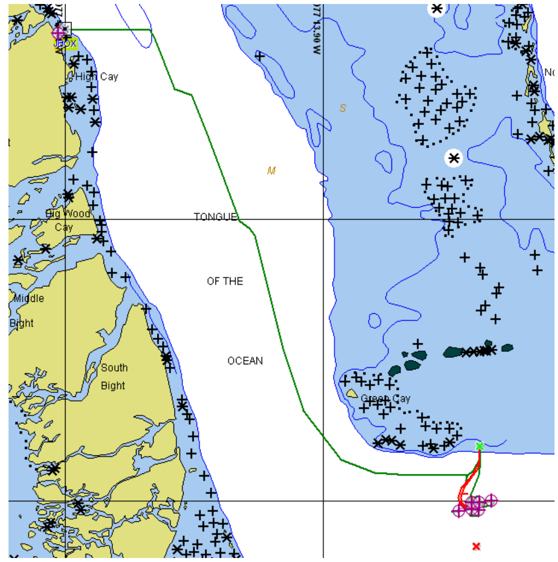

Figure 2 STAFAC Telecom Cables

Array Cables

There are two array cables, both extending from the STOTO J-box to the array site (one to the north array, and one to the south array). Each cable is an electro-optical telecom-type cable (similar to the trunk cable above). The total lengths of the North and South Array Cables are approximately 14 and 16 km, respectively. Both cables are double armored in the shallow water area of the STOTO J-box and down the escarpment, and single armored in the upper portion of the escarpment. The remaining portion of cable is SPA type cable.

Umbilical Riser Cables

The Umbilical Riser Cables are torque balanced cables used to transmit the signal/power from the array cables (described above) through the water column to the array components (connection at a depth of approximately 380 feet). This cable is a high density polyethylene (HDPE) coated , double armored, electro-optical-mechanical (EOM) cable produced by South Bay Cable.

The STAFAC System also incorporates a Tracking and Underwater Communications (TUC) sub-system. The TUC Cables are TYCO SL17 Cable segments that extend from the STOTO J-Box to the array site. Integral to this cable are TUC Bi-Directional Acoustic Nodes that provide positional data for tracking in addition to digital communications with vessels throughout the test site. The total length of this cabled array is approximately 33 km. The TUC cables consist of a TYCO SL17

DA TUC Tether Cable Segment from the J-Box to an SA to a SPA segment to the instrumented SPA array segment.

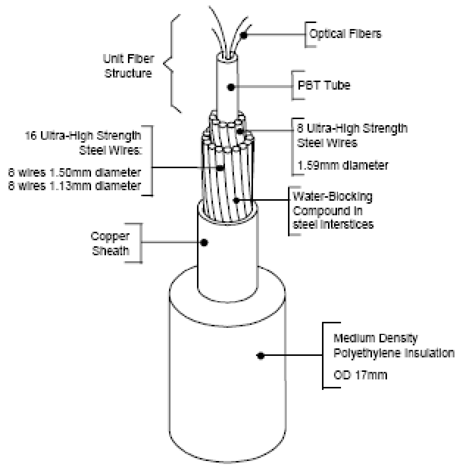

Figure 3-a TYCO SL17 Lightweight (LW)

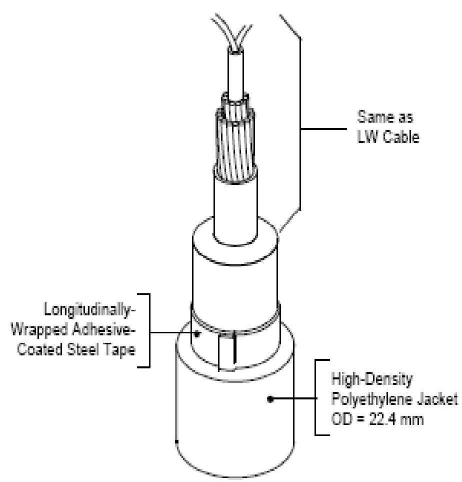

Figure 3-b TYCO SL17 Special Application (SPA)

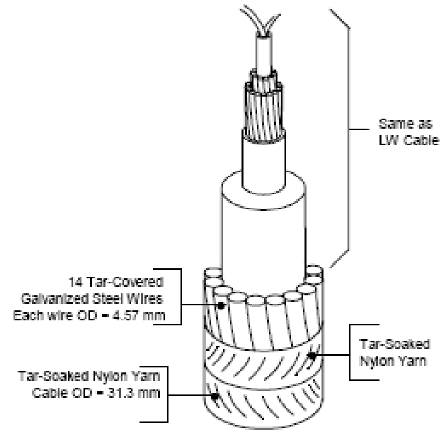

Figure 3-c TYCO SL17 Single Armor (SA)

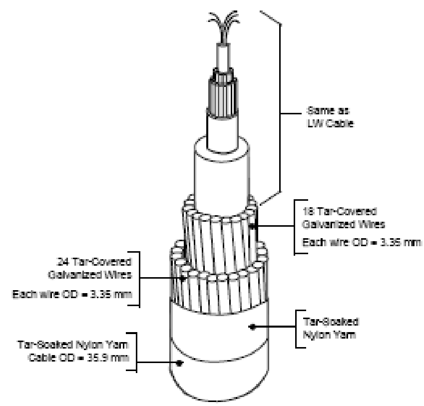

Figure 3-d TYCO SL17 Double Armor (DA)

STOTO Junction Box

An underwater junction box was necessary to manage and connect the four system cables (the trunk cable, two array cables, and one tracking cable). To minimize the amount of cable required for STAFAC, and provide easy access for serviceability, the junction box was located in 50 feet of water. Hinged doors are designed to allow diver access for underwater maintenance and inspection. The armor sections of the four TYCO SL17 DA cables are mechanically terminated on the front end of the J-Box Frame. Fifty feet of Cable Core (SL17 LW) service loop is secured within the J-Box enclosure, and custom terminated to the J-Box Instrumented Pressure Vessel (IPV) electronics housing. The electronics housing is approximately 21 inches in diameter and 60 inches long. **Figure 4** shows the Solid Works design of the STOTO J-Box. **Figure 5** is a photo of the J-Box installed on the ocean floor.

This J-Box Frame is designed to be stable on the seafloor while providing a means to be raised and lowered in a water depth of 50 feet. The junction box is raised and lowered with cables as an assembly with a hinge point on the seafloor as the installation vessel moves along the cable track.

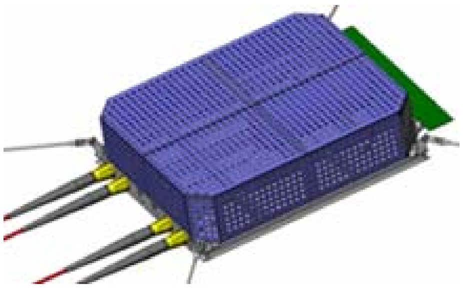

Figure 4 STAFAC Junction Box

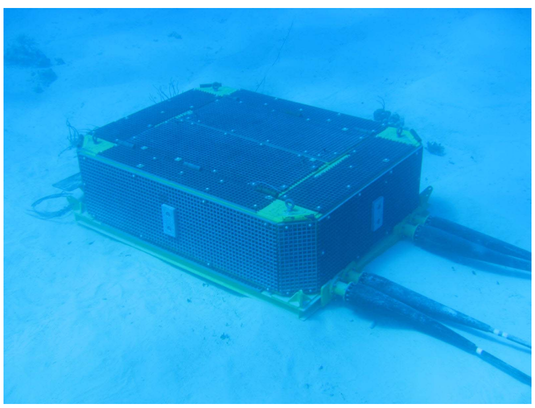

Figure 5 STAFAC J-Box Installed on Seafloor

Array Mooring Components

As illustrated in **Figure 6**, the STAFAC Arrays are fixed to the seafloor by a single four-point mooring, with two main mooring buoys connected by a “cross-wire.” The mooring assembly anchors both sensor strings at a fixed seafloor location and maintains their lateral separation at the specified distance of 280 (+20 – 0) yards, and at a differential depth tolerance of less than 10 feet.

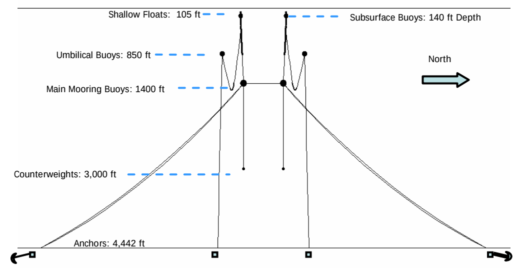

Figure 6 STAFAC Primary Mooring Configuration

The four-leg mooring is designed to hold two “false bottom” (main mooring) buoys as stationary as possible in all typical current profiles. Each buoy is made of syntactic foam with 12,000 lbs of buoyancy. A wire rope mooring line secures each anchor to each main mooring buoy. A “cross-wire” permanently holds the two main mooring buoys a fixed distance apart (to maintain accurate array separation). A plastic jacketed wire rope counterweight cable and a counterweight, consisting of stacked railroad wheels, was installed by passing the cable through a center hole in each main mooring buoy. A DELRIN stopper was fastened to the counterweight cable to mechanically adjust and set the depth of the array. This arrangement allows for easy lifting of the array for servicing, without moving the mooring or anchors and legs. The stopper enables the array to be automatically repositioned vertically when it is lowered back into its socket. All mooring legs are structural only, with no incorporated telemetry or power cables required. To provide fish-bite protection, the mooring lines and counterweight cables are 5/8 inch diameter NILSPIN Wire Rope. The cross-wire and interconnecting array wires are ¾ inch NILSPIN.

Each array main mooring segment is anchored to the bottom of STOTO at a depth (referenced to the center of the arrays) of approximately 4400 feet. Figure 6 shows the nominal design anchor positions for the four- point mooring and two umbilical cables. Main mooring clump weight anchors with Bruce drag embedment anchors were selected to resist the resultant vertical and horizontal reaction loads. The clump anchor resists the entire vertical component of the load and acts as a depressor for the Bruce anchor, which in turn provides all of the horizontal resistance.

Photos of the Bruce Anchors and the main mooring clump anchors are shown in **Figures 7 and 8.**. The clump and Bruce anchors are arranged in tandem, connected by 1-½ inch chain.

Figure 7 Main Mooring Bruce Anchors

Figure 8 Main Mooring Clump Anchor

The four mooring anchors (dry weight 8,650 lbs), were connected by 30 feet of 1-½ inch chain, to a Bruce drag anchor (dry weight 3,300 lbs), with another 30 feet of 1-½ inch chain to the mooring wire rope as shown in **Figure 9**. This arrangement efficiently resists both the vertical and lateral tension in the oblique mooring legs.

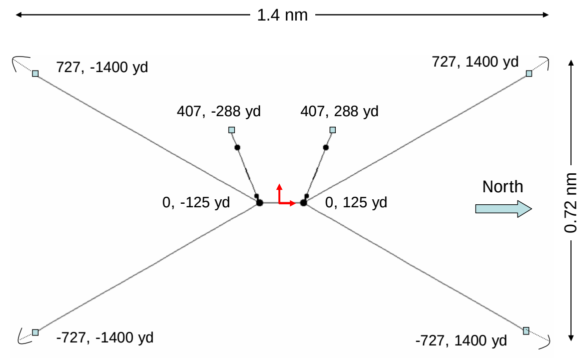

Figure 9 Nominal Mooring Anchor Positions

Umbilical Anchors

Stacked railroad wheels were used to fabricate the umbilical anchors, as shown in **Figures 10 and 11**.

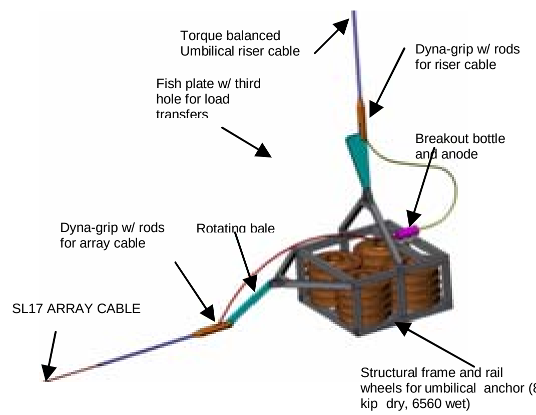

Figure 10 Umbilical Anchor Design

Figure 11 Umbilical Anchor Prior to Installation

Mooring Lines

Wire ropes are used to connect between the anchors and main mooring buoys. Main anchor leg lengths are 5400 feet, sufficient to install the anchors to the bottom in 4400 feet of water. NILSPIN 3x19 plastic jacketed wire rope was chosen, (1) to eliminate fish bite concerns, (2) for its torque balance properties, and (3) for its corrosion resistance.

Main Mooring Buoys

The two Main Mooring Buoys provide tension to stabilize the 4-point Primary Mooring and to support the Counterweights. They also provide positioned through-points for the Counterweight Cables to secure, via the Counterweight Stoppers, the two HGMS Arrays, as shown in Figure 9.

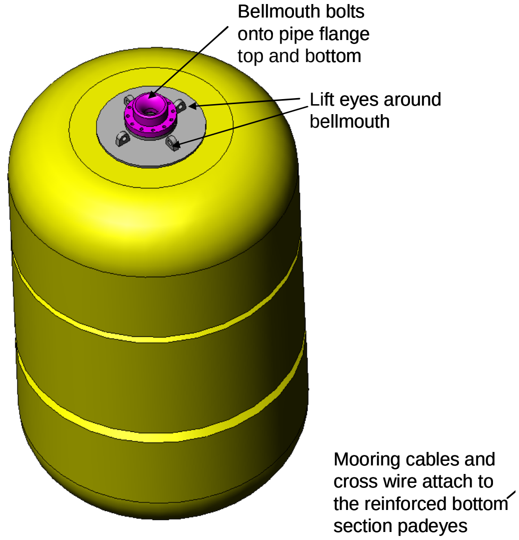

Figure 12 Main Mooring Buoy

The Main Mooring Buoy Assemblies, shown in **Figures 12 and 13**, each consist of a cylindrical, 7 foot diameter by 10 foot high syntactic foam filled polyethylene molded shell. The net buoyancy of the assembly is approximately 12,000 lbs. The main mooring buoys are located at approximately 1400 feet depth or 3050 feet above the seafloor. Each main mooring buoy assembly weighs approximately 10,000 lbs in air.

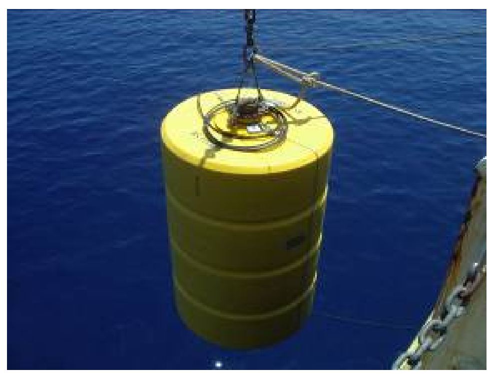

Figure 13 Main Mooring Buoy Installation

Umbilical Buoys

There are two Umbilical buoys, each consisting of a segmented syntactic foam cylinder, with 8,000 lb net buoyancy (**Figure 14**). Both buoys are 96 inches diameter by 64 inches high. The two umbilical cables were secured to the seafloor with the two umbilical anchors (in-air weight 9,000 lbs). At the anchor, these vertical umbilical cables were spliced to the bottom laid SL17 telecom array cables with a custom designed electro-optical-mechanical splice.

Figure 14 Umbilical Buoy Frame Detail

Umbilical Limiting Frame

An Umbilical Bend Limiting Frame was secured to the base of the buoy to connect and manage the minimum bend radius of the umbilical cable during deployment and operation for the life span of 15 years . The configuration of the bend limiter is shown in **Figure 15**. The Frame design, shown in **Figure 16**, incorporated two Preformed Marine in-line Dyna-Hangers, custom designed to allow limited rotation within the within the Frame mounting structure.

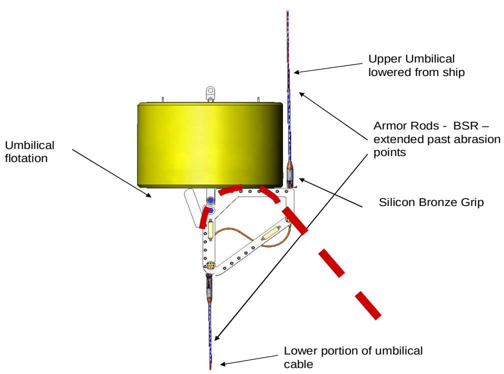

Figure 15 Bend Limiter Configuration

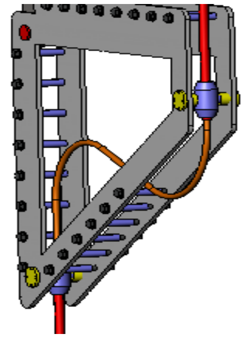

Figure 16 Bend Limiter Frame Design

High Gain Array Assembly and Support Buoys

The High Gain Arrays are approximately 900 feet long, and are populated with approximately 800 acoustic sensors. Each array assembly is supported in the water column by Sub-Surface Buoys. These cylindrical buoys are 83 inch diameter by 88 inches high syntactic foam filled polyethylene shells, mounted on a steel center strength member. The net buoyancy is 10,000 pounds. They are located at a nominal depth of 135 feet. A smaller, 36 inch diameter spherical buoy is attached above this to provide for an upper acoustic sensor at a relatively shallow depth but safe for shipping traffic. This buoy was constructed with very high density syntactic foam to minimize acoustic reflections.

Figure 17 Sub-Surface Buoys

CONCLUSIONS

The designs of the STAFAC in-water systems followed basic ocean engineering principles. Dissimilar metals were isolated to prevent galvanic corrosion, materials were selected to meet the system life requirements in the ocean, and stress analyses were conducted for all loaded structures.

The Umbilical Buoys were uniquely designed to support the Umbilical Cables during deployment, service, and retrievals. The modified PMI Dyna-Hangers provided two pivot points to allow the cable to follow the curvature from the taut buoyed riser to the weighted catenary section without violating the minimum bend radius of the electro-optical-mechanical cable.

This unique umbilical – counterweight system design allows the arrays to be retrieved and re-installed without ever having to lift any anchors off the bottom, reducing deck gear requirements and eliminating the need for a precision USBL system, used for the initial installation.

The STAFAC system is a robust design that fulfills the requirements and includes flexibility for future servicing and replacement of components if required.

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